



Industrial Heat Pumps in Japan

- Current status and future prospects -

Takenobu Kaida

Toshihiro Mukai

Central Research Institute of Electric Power Industry (CRIEPI)

Tsuyoshi Hamayashiki

Japan Electro-Heat Center (JEHC)

- Technology status
 - Market available industrial heat pumps
 - Under development high-temperature heat pumps
- Market Status
 - Policy indicator
 - Actual installations
- Barrier analysis
 - Questionnaire survey to industries
- Possible solutions

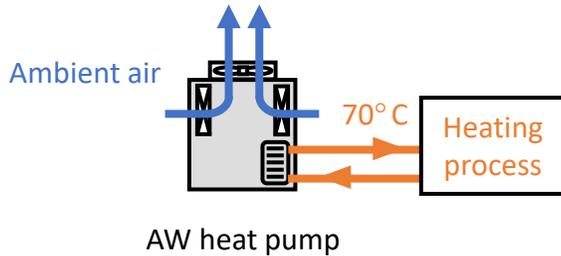


Technology Status: Market available industrial heat pumps



Air-source heat pumps

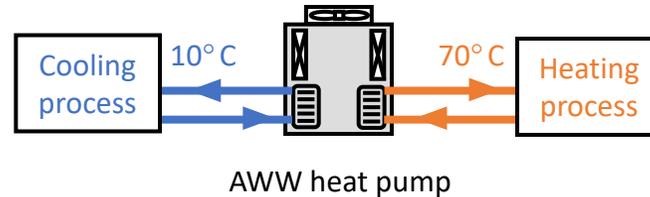
- Mainly intended to be distributed to each heating process



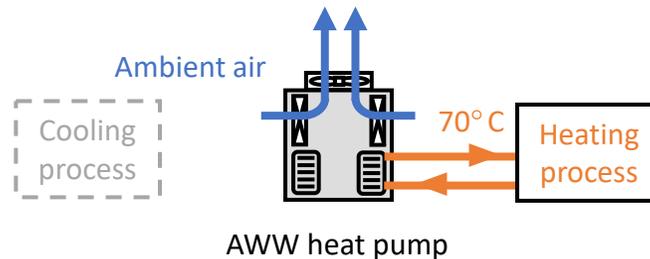
Air- and water-source heat pumps

- Used for simultaneous heating and cooling without thermal storage

< Simultaneous heating and cooling mode >



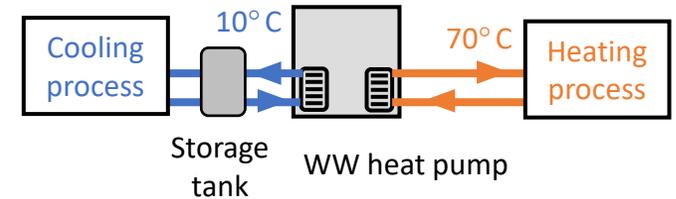
< Heating mode >



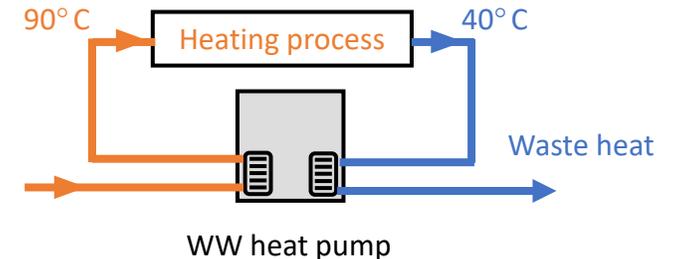
Water-source heat pumps

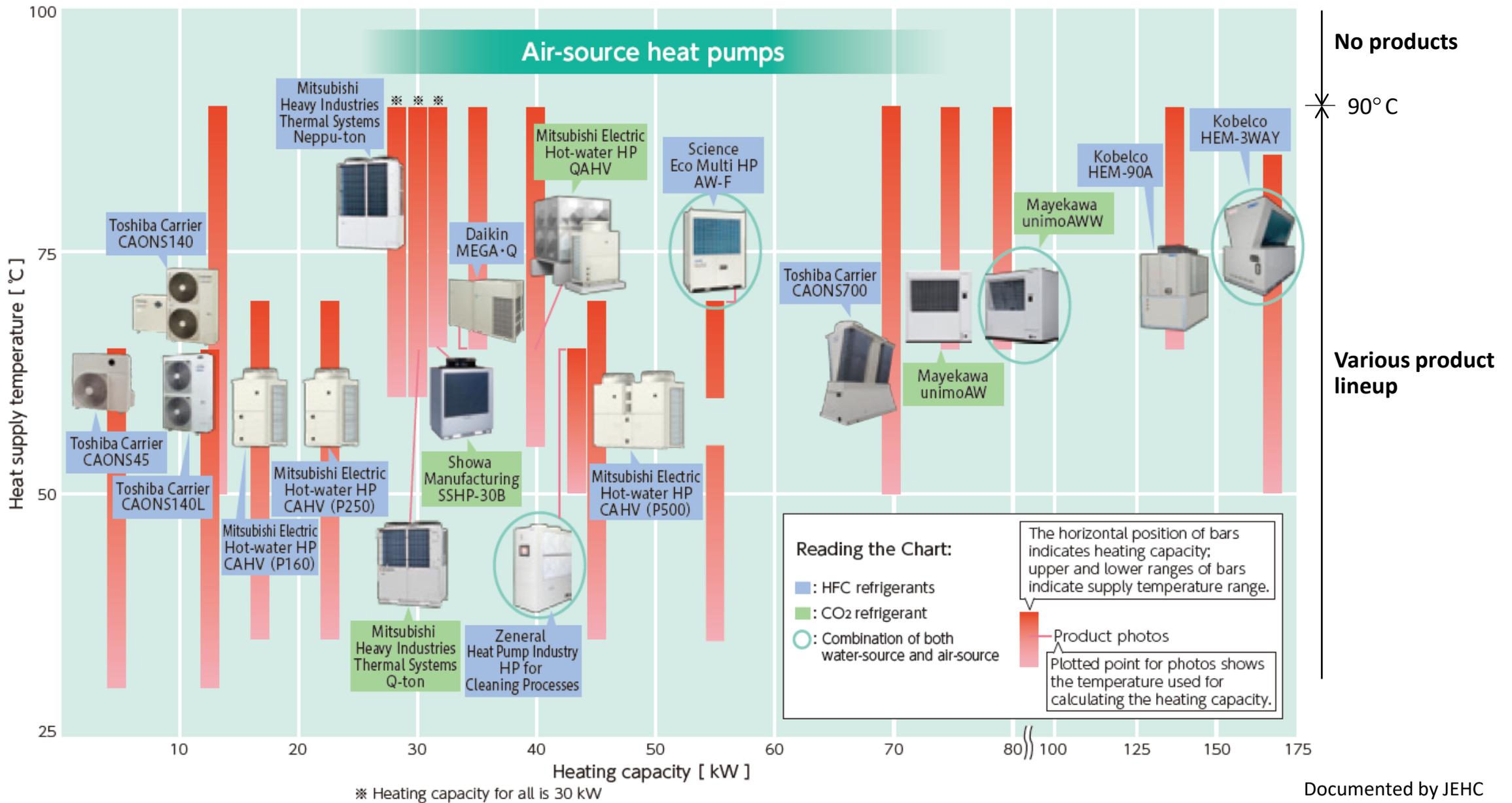
- Used for simultaneous heating and cooling or waste heat recovery

< Simultaneous heating and cooling system >

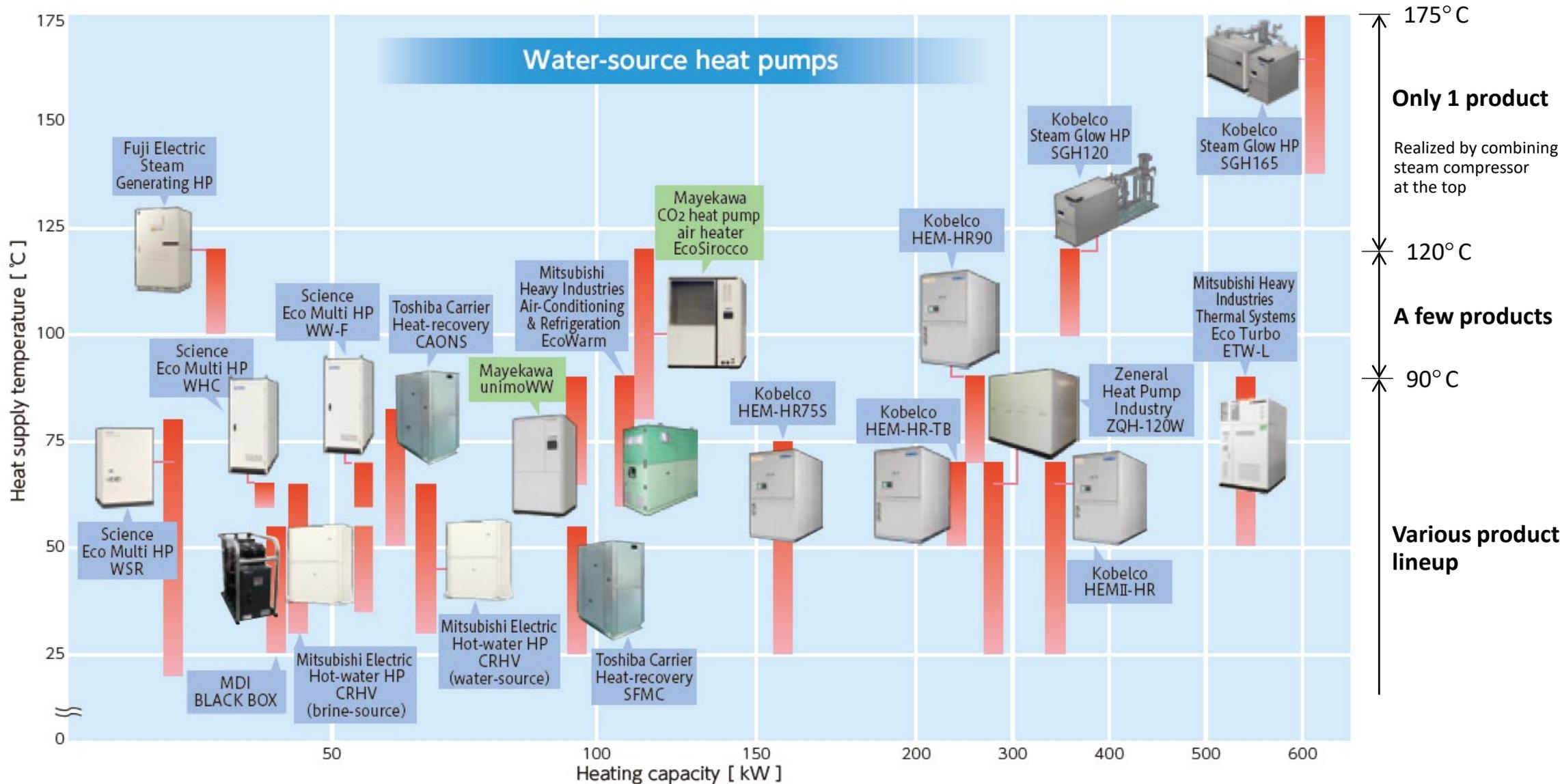


< Waste heat recovery system >





Documented by JEHC



Documented by JEHC



Technology Status: Development perspectives



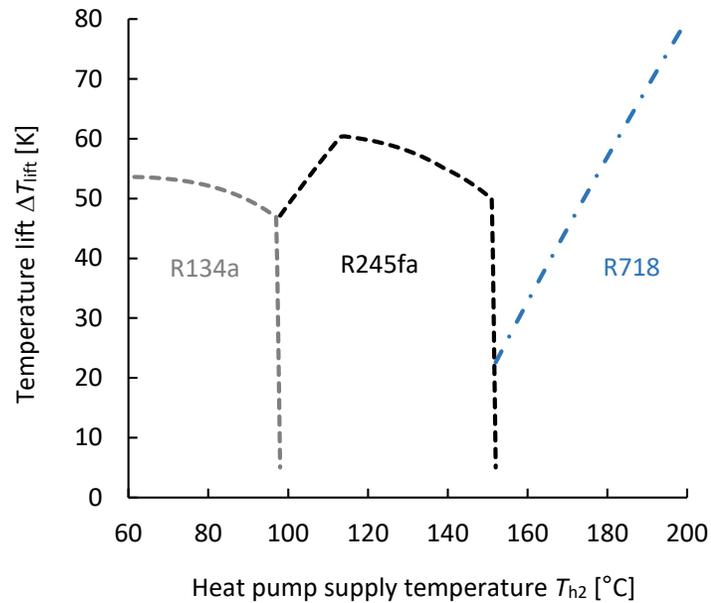
In Japan, various types of industrial heat pumps with a wide range of specifications have been commercialized. However, the following technological developments are still necessary.

- Lower GWP refrigerants
 - HFCs → HFOs, HCFOs or Natural refrigerants
- Higher temperature supply
 - Supply temperature above 120°C
 - Becoming possible with newly-developed refrigerants
- Lubricant oils for high-temperatures or lubricant-free technologies

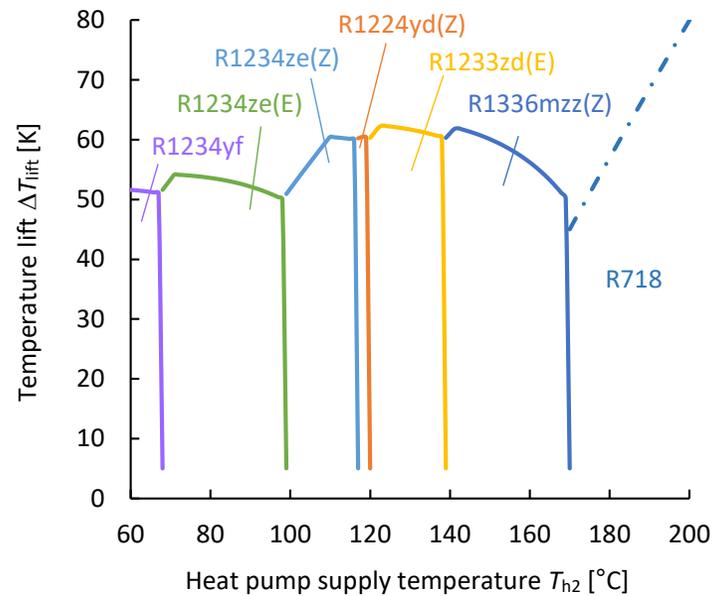
Working domain analysis

(2-stage economizer cycle, $\Delta T_h = \Delta T_c = 5$ K, COP ≥ 4 , VHC ≥ 2 MJ/m³)

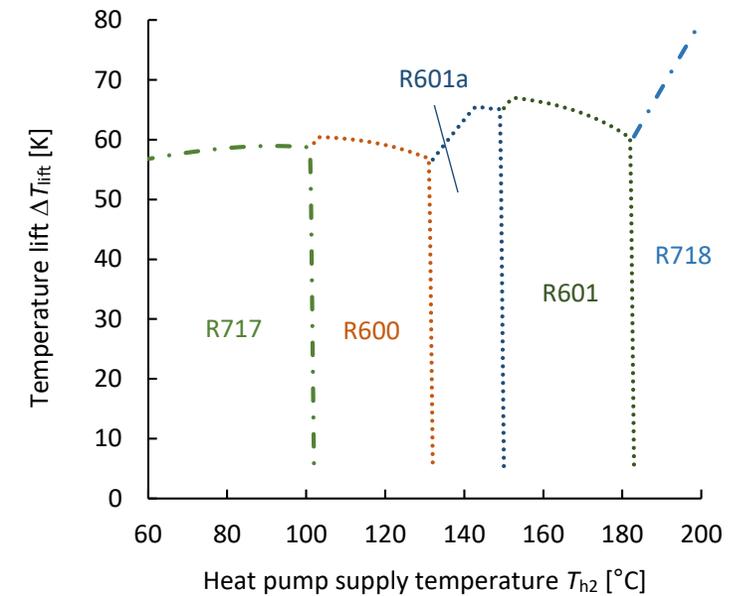
HFCs and R718 (10 years ago)



HFOs, HCFOs and R718 (Current)



Natural refrigerants (if accepted)



T. Kaida, Thermodynamic analysis of refrigerant selection for high temperature heat pump cycles, 13th IEA Heat Pump Conference, Jeju, Korea, April 2021.



Technology Status: Under development high-temperature HPs



Manufacturer	Fuji Electric	Mayekawa	Mayekawa	Mitsubishi Heavy Industries Thermal Systems	Mitsubishi Heavy Industries Thermal Systems
Supply temperature	120-150°C (steam)	150°C (steam)	180°C out / 80°C in	160°C out / 70°C in	200°C out / 100°C in
Heat source temperature	60-90°C	80°C	80°C	80°C	95°C
Heating capacity	30 kW	260 kW	500 kW	600 kW	600 kW
Refrigerant	R1336mzz(Z)	R601 (pentane)	R600 (butane) or R1336mzz(Z)	R1336mzz(Z)	HFE356mmz
Compressor	Scroll	Screw	Centrifugal	Centrifugal	Centrifugal



Market Status: Two statistics for installations

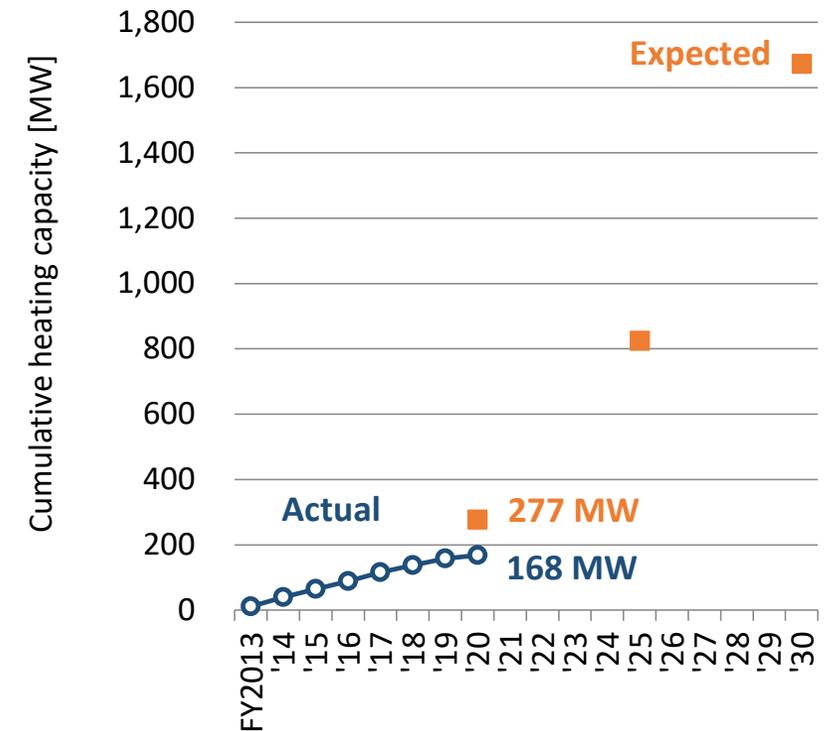


Publication	MOE (Ministry of Environment)	JEHC (Japan Electro-Heat Center)
Surveyed organization	<ul style="list-style-type: none">• METI (Ministry of Economy, Trade, and Industry)• JRAIA (Japan Refrigeration and Air Conditioning Industry Association)	<ul style="list-style-type: none">• JEHC (Japan Electro-Heat Center)• Fuji Keizai
Purpose	Policy indicator	Basic material for promotion
Coverage	7 suppliers	24 suppliers
Items	<ul style="list-style-type: none">• Total capacity	<ul style="list-style-type: none">• The capacity and number of units for each heat pump category• Installed industries and processes



Market Status: Policy indicator

- “The Plan for Global Warming Countermeasures”
 - Decided by the Cabinet in May 2016
 - 46%* reduction of GHG emissions by FY2030 compared to FY2013
 - * It was 26% reduction when originally announced in May 2016, but it was revised to 46% reduction in April 2021.
- Role of industrial heat pumps
 - Over 150 times spread (11 MW in FY2013 to 1,673 MW in FY2030)
 - 1.35 million ton-CO₂ reduction (= 0.4% of total GHG emissions reduction)

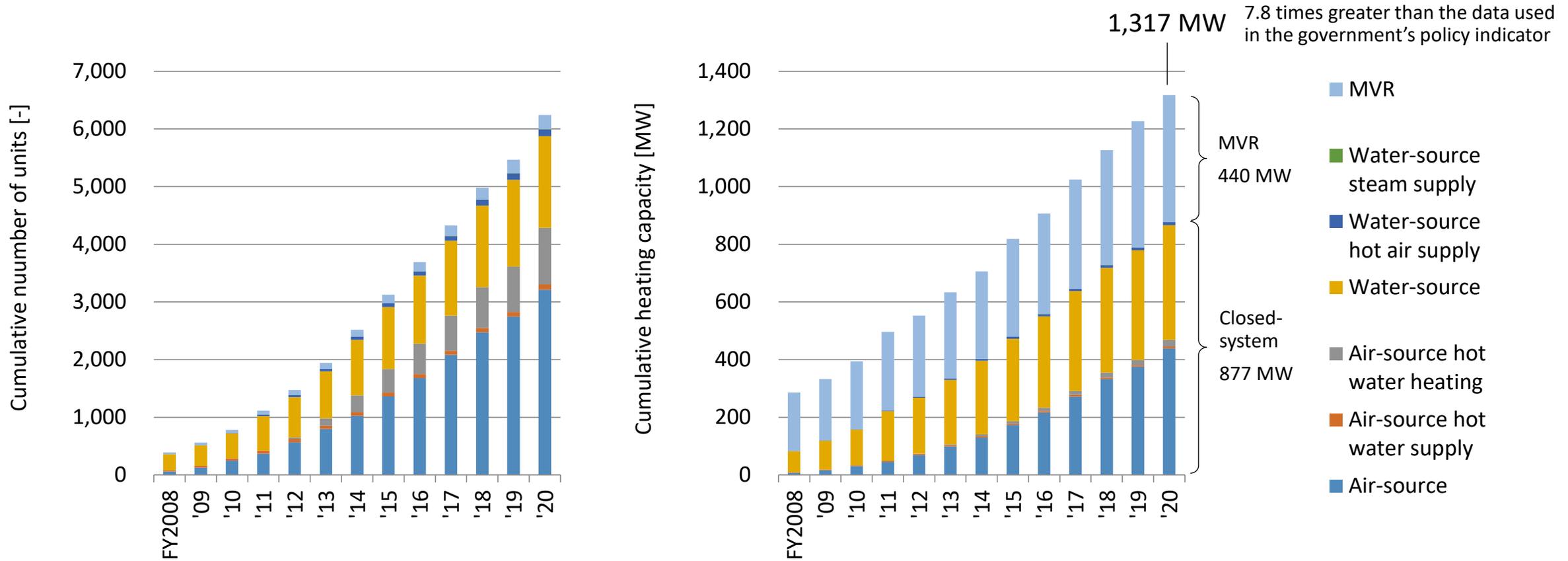


Necessary to accelerate the installations

Documented by MOE



Market Status: Entire installation of industrial heat pumps



Documented by JEHC

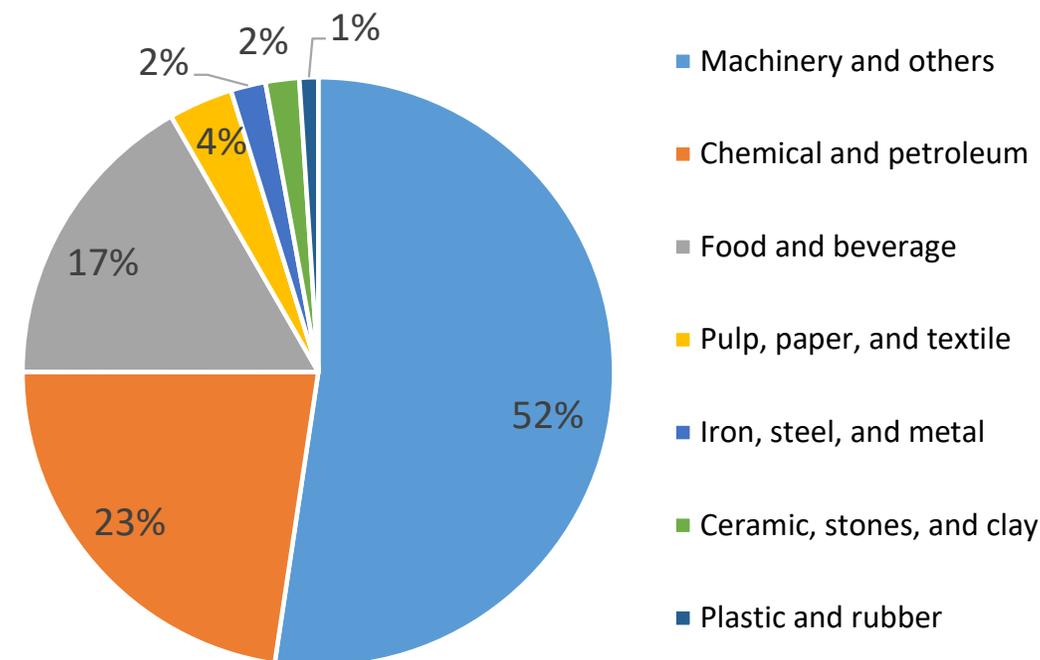


Market Status: Installed industries and processes



- Closed-system heat pumps
 - Washing and drying in machinery and electronics industry
 - Washing, sterilization and keeping warm in food, beverage, pharmaceutical and chemical industry
- MVRs
 - Concentration in food and beverage
 - Concentration for waste liquid treatment
 - Concentration for recovery of valuable materials
 - Distillation in chemical industry
 - A few steam drying processes

Installed industries for closed-system industrial heat pumps



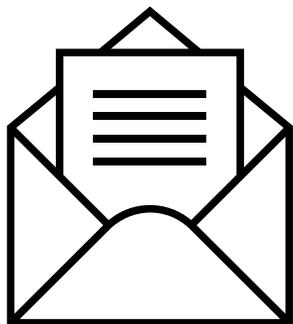
A breakdown of 186 MW of installed industries out of the total capacity of 877 MW



Barrier Analysis: Questionnaire survey summary



- Assessing the relevance of barriers to electrification (including heat pumps) in industry to consider appropriate support measures in Japan.



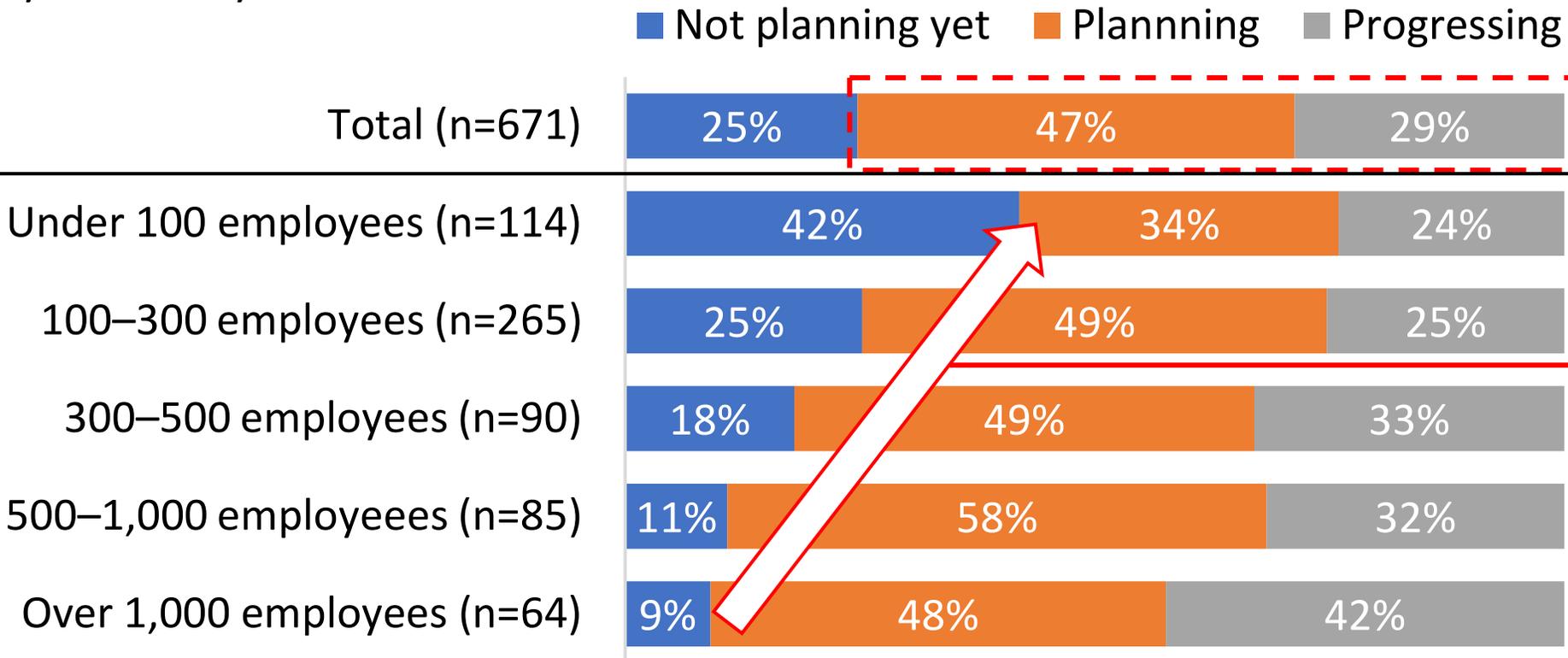
- Survey subject:
Factories with high energy consumption in which periodic reports of energy consumption are mandated by the Japanese government (by the Energy Efficiency Act)
- Method: Paper questionnaires were mailed
- Period: October 15 – November 5, 2021
- Valid responses: 690 of 6,016 mailed (response rate 11.5 %)



Survey results: Efforts towards decarbonization



Q1. Are you currently planning or making progress towards decarbonization in your factory?



75% of respondents are making efforts or making plans for decarbonization.

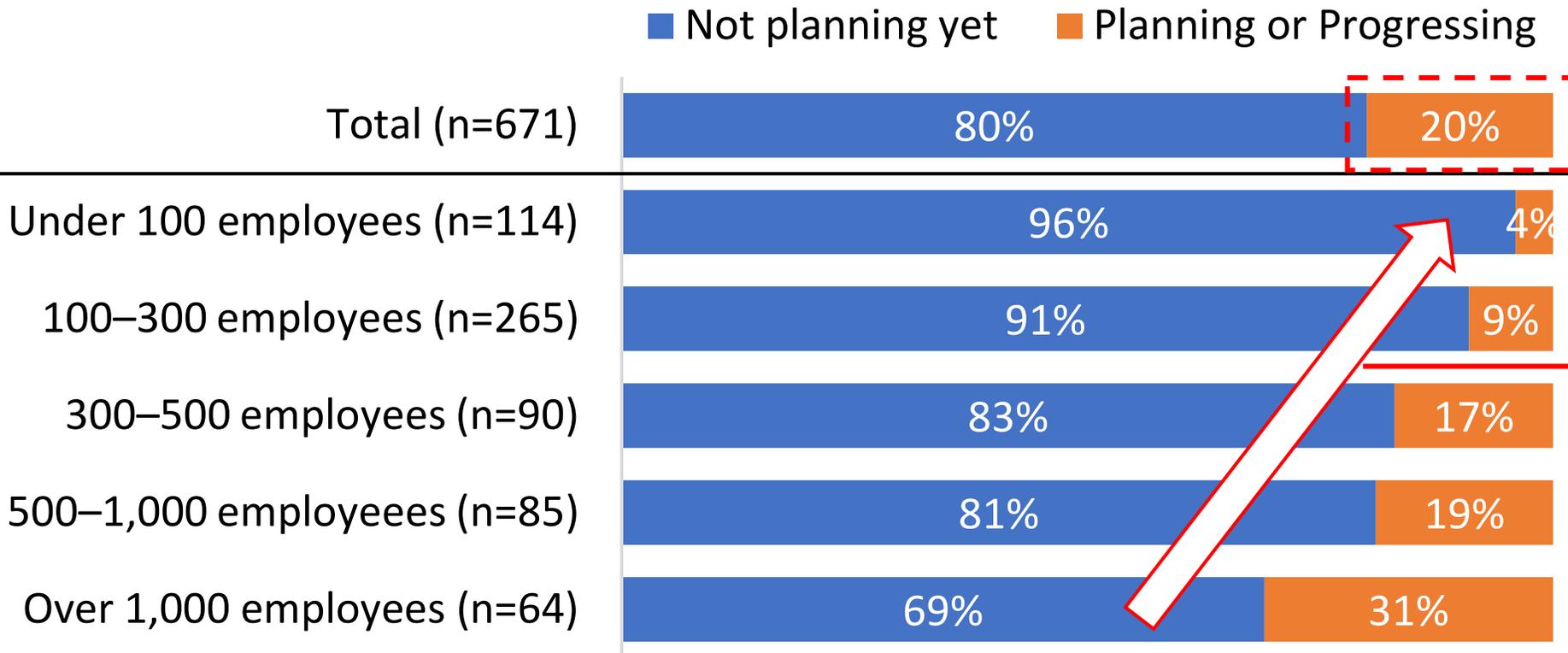
However, companies with fewer employees (SMEs) seem to be less active.



Survey results: Efforts towards electrification



Q2. Are you currently planning or making progress towards electrification?



Only 20% of respondents are making efforts/plans for electrification (including heat pump installation)

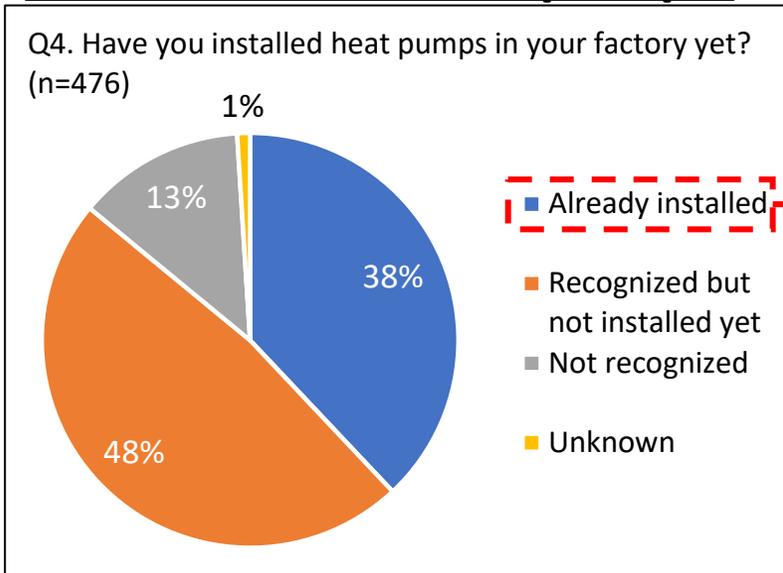
Companies with fewer employees (SMEs) seem to be less active.



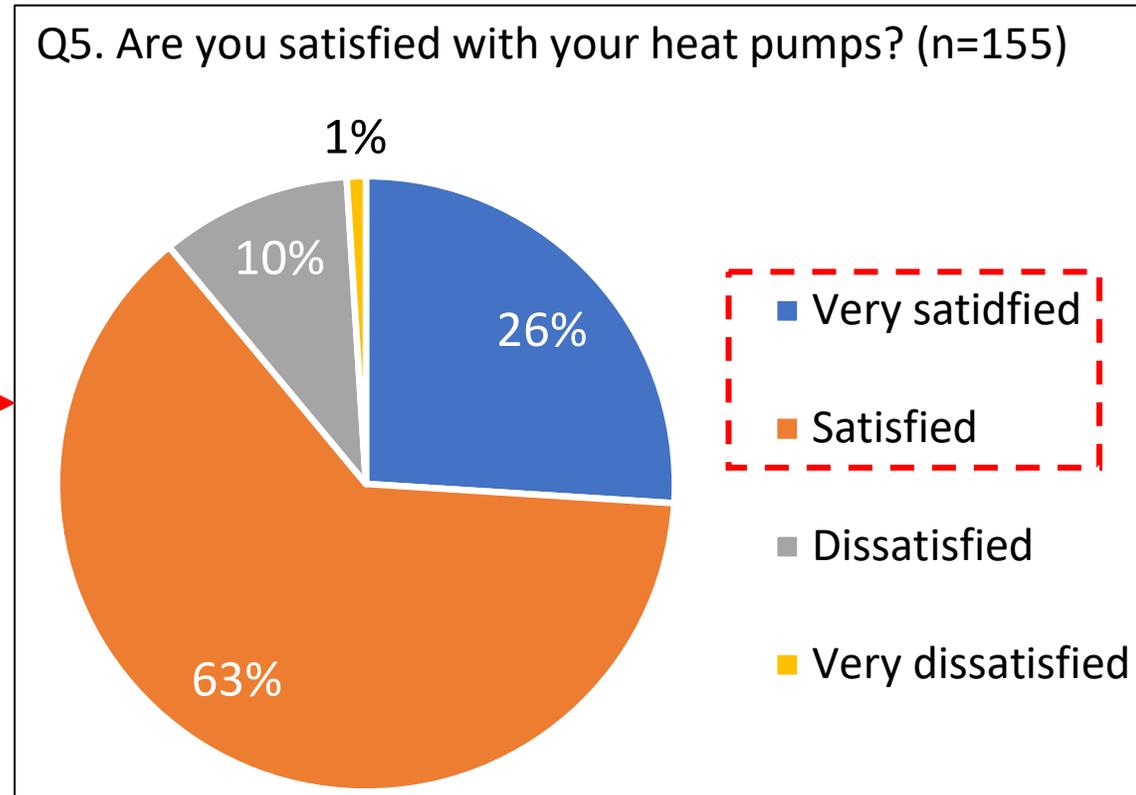
Survey results: Satisfaction to heat pumps technologies



38% of respondents
have installed heat pumps.



89% of the respondents that have already installed
are satisfied with their heat pump technologies.





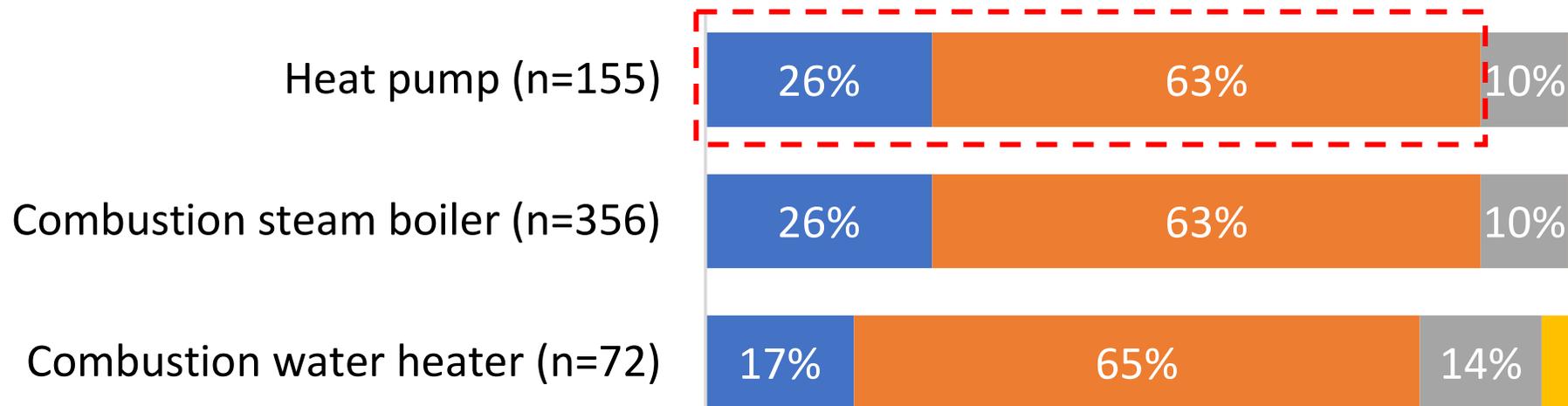
Survey results: Satisfaction compared to combustion heaters



- Compared to combustion technologies (steam boilers and water heaters), heat pumps have almost same degree of satisfaction.

Q6. Are you satisfied with your heating equipment?

■ Very satisfied ■ Satisfied ■ Dissatisfied ■ Very dissatisfied



Note:

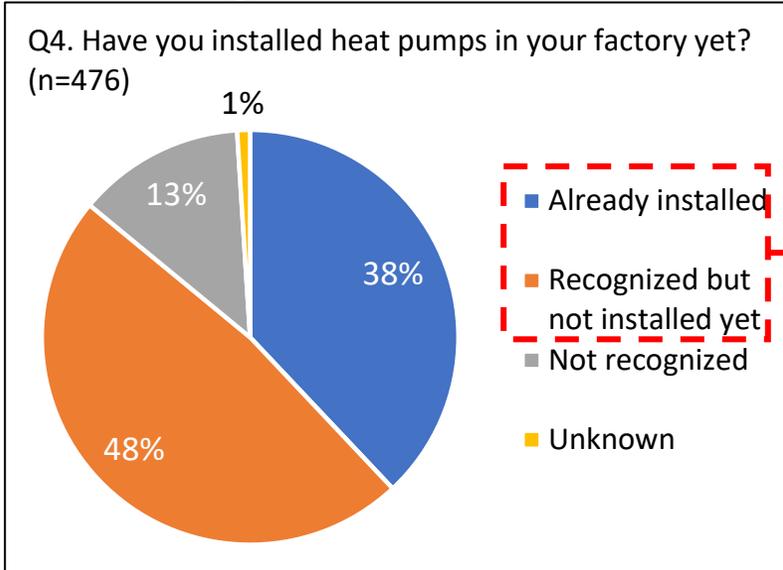
- Most of the heat pumps installed by respondents are supplying heat below 100 degrees Celsius
- Combustion technologies can supply below/above 100 degree Celsius



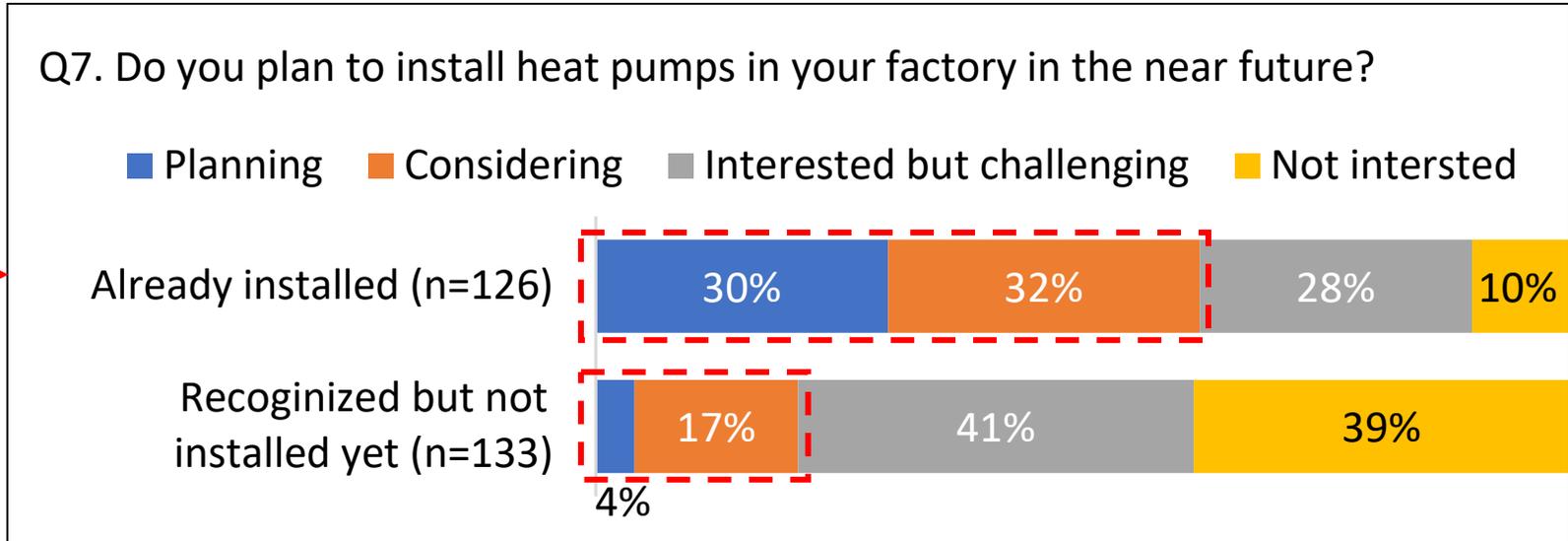
Survey results: Willingness to install (additional) heat pumps



48% of respondents know the technologies but not installed yet.



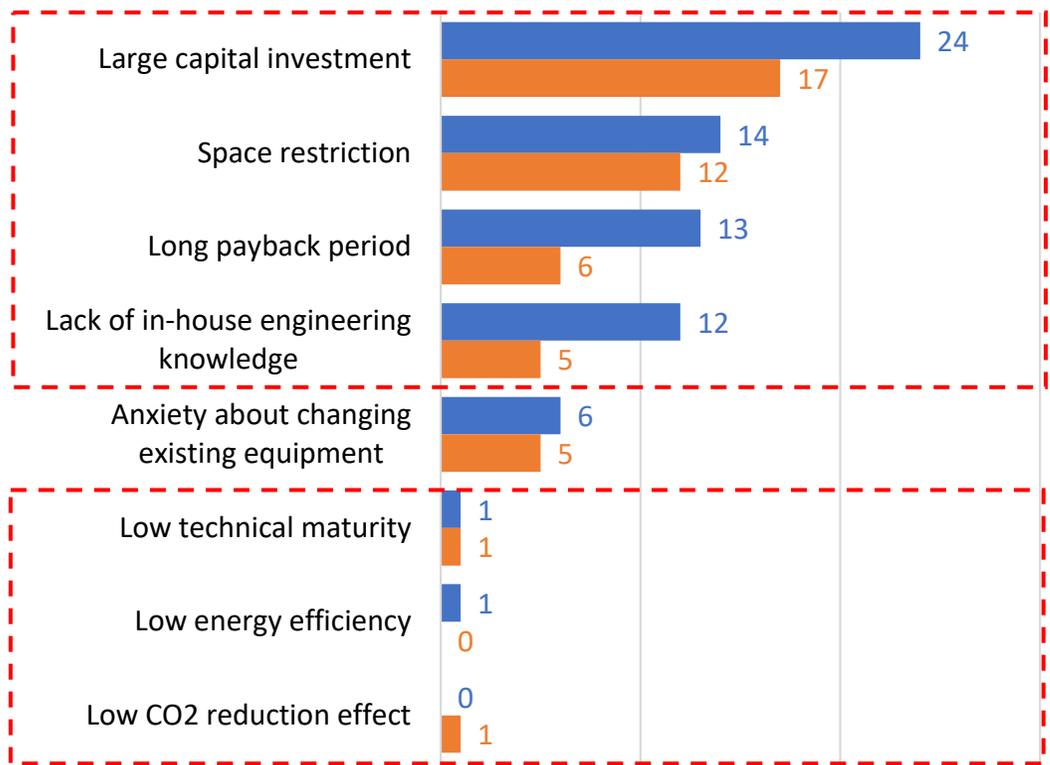
- 62% that have already partially installed heat pumps are planning/willing to plan additional installation (implying high satisfaction increase further adoption).
- Conversely, only 21% that have not yet installed are planning/willing to plan heat pump installation.



Survey results: Relevant barriers to heat pumps installation

Q8. What reasons are making you reluctant to install heat pumps?
(multiple choices allowed)

■ Already installed ■ Recognized but not installed yet



- Highly relevant barriers to heat pump installation
 - ✓ Large capital investment
 - ✓ Space restriction
 - ✓ Long payback period
 - There are respondents only concerned about large capital investments (but not long payback periods), implying that favorable financing arrangements could help to overcome the barriers.
 - ✓ Lack of in-house engineering knowledge
- Many companies are satisfied with the technical maturity (high energy efficiency) of heat pumps.



Implications: Relevant barriers and policy options



Relevant barriers	Current status	Policy options
High capital investment	<ul style="list-style-type: none">• The most relevant barrier in Japan is capital expenditure.• Companies with fewer employees (SMEs) are facing difficulties.	<ul style="list-style-type: none">• <u>Subsidies</u> supporting capital investment (especially targeting SMEs) are needed.• Approaches that <u>reduce time & efforts of the subsidy application</u> may help SMEs with limited resources.
Space restriction	<ul style="list-style-type: none">• It is difficult to address the lack of installation space in existing factories.	<ul style="list-style-type: none">• Technical & financial supports <u>targeting newly built factories</u> are needed to make industry heat pump-ready.
Long payback period	<ul style="list-style-type: none">• Electricity is (unfairly) highly taxed/levied compared to fossil fuels.	<ul style="list-style-type: none">• <u>Rebalancing taxes & levies</u> between electricity and fossil fuels, such as rebalancing renewable energy levy.
Lack of engineering knowledge	<ul style="list-style-type: none">• Many companies lack the necessary knowledge and skills to integrate heat pumps into their processes or utilities.	<ul style="list-style-type: none">• It is necessary <u>to strengthen the demonstration and deployment projects</u> for establishing process integration methodology and to cultivate process integrators.



Future Projects: From development to deployment



- National projects of Japan have focused on technological developments so far.
- Successfully improved the technical potential and maturity of heat pumps
- However, lack of demonstration and deployment projects

Stage	Main actor	TherMAT (JP)	BAMBOO (EU)	DryF (EU)	SuPrHeat (DK)	LEAP (AT)
Research	Research institute University	✓	✓	✓	✓	
Development	Manufacturer	✓	✓	✓	✓	
Demonstration	End-user Engineering company		✓	✓	✓	✓
Deployment	Energy service company				✓	✓
Dissemination	Heat pump association			✓		

- Technology status
 - Already market available for various types of industrial heat pumps
 - Still necessary to develop lower GWP and higher temperature supply heat pumps
- Market status
 - Gradually installed, but rate of adoption has not progressed as anticipated
- Barriers and solutions
 - To faster widespread adoption, imperative to mitigate economic and site-specific obstacles
 - Support capital investment, mainly targeting SMEs
 - Rebalance the renewable energy levy to lower electricity to fuels price ratio
 - Encourage the introduction of heat pumps in new factories
 - Strengthen demonstration and deployment projects with involving end-users, engineering companies and energy service companies

Thank you for your attention.